

# HUMAN FACTORS AND BEHAVIORAL PERFORMANCE EXPLORATION MEASURES IN NEK-SIRIUS 21

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# Human Factors Behavioral Performance (HFBP) Exploration Measures



Human Exploration Research Analog (HERA)



International Space Station (ISS)



Russian Ground Based Experiment Complex (NEK)

Photo credits: NASA, NEK-  
IBMP/Oleg Voloshin

## HFBP-EM

### *Physiology/Biomarkers*

Sleep  
Heart Rate

### *Individual Behavioral Health*

Personality Assessment  
Social Desirability  
Depression  
Mood and Affect  
Neurobehavioral Function

### *Objective Performance*

Cognition  
ROBoT

### *Team & Social Dynamics*

Team Performance: MCC Ratings  
Team Performance: Crew Ratings  
Team Cohesion  
Team Processes  
Psychological Safety  
Social Support  
Group Living

# Scientific International Research In a Unique terrestrial Station (SIRIUS) 21

Campaign Manipulation	Crew	Mission Scenarios	Days in mission	Habitat Size	Off-nominal events
Three 36-hr sleep deprivations (MD55, MD115, MD235)	1, 6-person crew (3 male, 3 female); multinational	Three lunar landing EVAs (Md61-65, MD122-126, MD190-194)	240	550 m <sup>3</sup>	Crewmember early egress MD32



Exterior of NEK habitat



NEK interior lounge area



Crewmember completing ROBoT-r



## Specific Aims

1. Assess Operational Feasibility of HFBP-EM in the Russian NEK space analog.
2. Assess Operational Acceptability of HFBP-EM in the Russian NEK space analog.
3. Provide a set of HFBP-EM for data-sharing with intramural and extramural investigators to use in proposed projects.
4. Enable comparisons of multiple missions across spaceflight analog campaigns to quantify risk using reliable metric-based data.
5. Contribute to HFBP-EM database for data-mining and integrative modeling and increase research data quality and transfer to LSDA.
6. Provide an assessment of behavioral and health performance impacts of habitat layout and acceptability.
7. Provide a comparative assessment of individual and crew functioning in isolation with measures taken in the participants' preferred language with those collected in English.
8. Examine the extent to which a monthly retrospective sleep quality index relates to daily subjective and objective sleep measures, as well as subjective ratings of neurobehavioral functioning and mood over time.

***Supplemental Aim:*** Assessing impact of crewmember early egress.



# Presentation Focus

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# Aim 1 Results

1. Assess Operational Feasibility of HFBP-EM in the Russian NEK space analog.

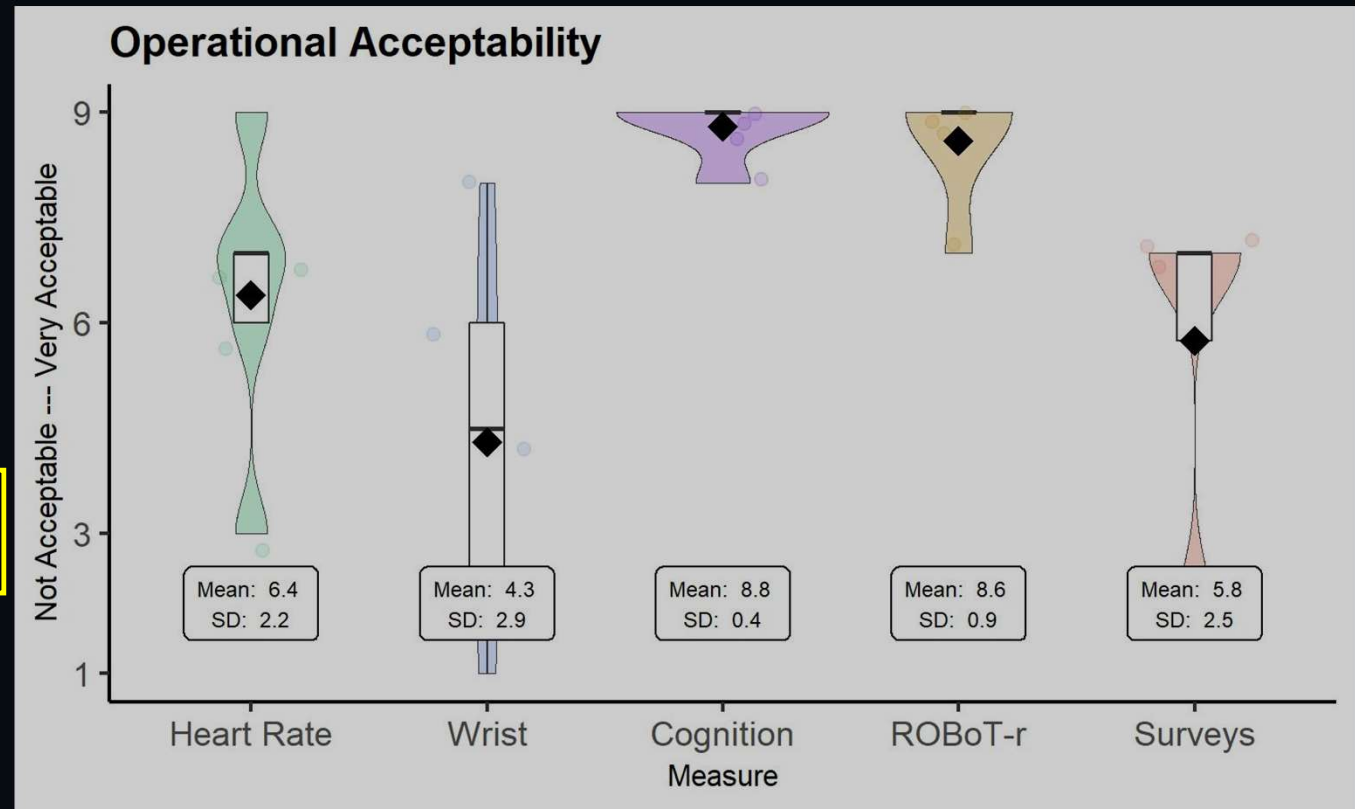
Operational feasibility overall high

	Mission Phase				Final Data Yield
	Pre-Mission	In-Mission	Post-Mission		
Physiology/Biomarkers					
Actigraphy	Continuous 24/7	Continuous 24/7	Continuous 24/7	95.7%	
Heart Rate	2 Continuous 14-day periods	Continuous 16 hrs/daily	2 Continuous 14-day periods	100%	
Individual Behavioral Health Surveys					
Personality Assessment	1x			100%	
Social Desirability Scale	1x			100%	
Beck Depression Inventory	Bi-weekly	Monthly	1x	92%	
Morning Mood and Affect (Neurobehavioral)	Every 3 <sup>rd</sup> day	Every 3 <sup>rd</sup> day	Every 3 <sup>rd</sup> day	91%	
Evening Mood and Affect (Neurobehavioral and Profile of Mood States)	Every 3 <sup>rd</sup> day	Every 3 <sup>rd</sup> day	Every 3 <sup>rd</sup> day	83%	
Pittsburg Sleep Quality Index	3x	Monthly	2x	97%	
Team & Social Dynamics Surveys					
Team Performance (MCC)	N/A	Every 3 <sup>rd</sup> day	N/A	78%	
Team Performance (Crew) and Team Cohesion	Every 3 <sup>rd</sup> day	Every 3 <sup>rd</sup> day	Every 3 <sup>rd</sup> day	92%	
Team Processes	Bi-weekly	Bi-weekly	Bi-weekly	99%	
Psychological Safety	Bi-weekly	Bi-weekly	Bi-weekly		
Social Support	4x	Every 20 days	1x	96%	
Group Living	NA	Every 20 days	NA		
Habitability Survey					
Habitability Acceptability Home	Every 28 days	Monthly	1x	99%	
Habitability Acceptability Home/Hotel	Every 28 days	Monthly	1x	78%	
Habitability Acceptability Hab/Lunar	Every 28 days	Monthly	1x	61%	
Behavioral Performance					
Cognition	3x	Bi-weekly	3x	97%	
ROBoT-r	3x	Bi-weekly	3x	91%	

## Aim 2 Results

2. Assess Operational Acceptability of HFBP-EM in the Russian NEK space analog.

Operational acceptability mixed





## Aim 4 Results

4. Enable comparisons of multiple missions across spaceflight analog campaigns to quantify risk using reliable metric-based data.

- Results for:
  - Sleep
  - Mood
  - Cognitive performance
  - Behavioral performance
  - Comparisons across multiple spaceflight/analog missions



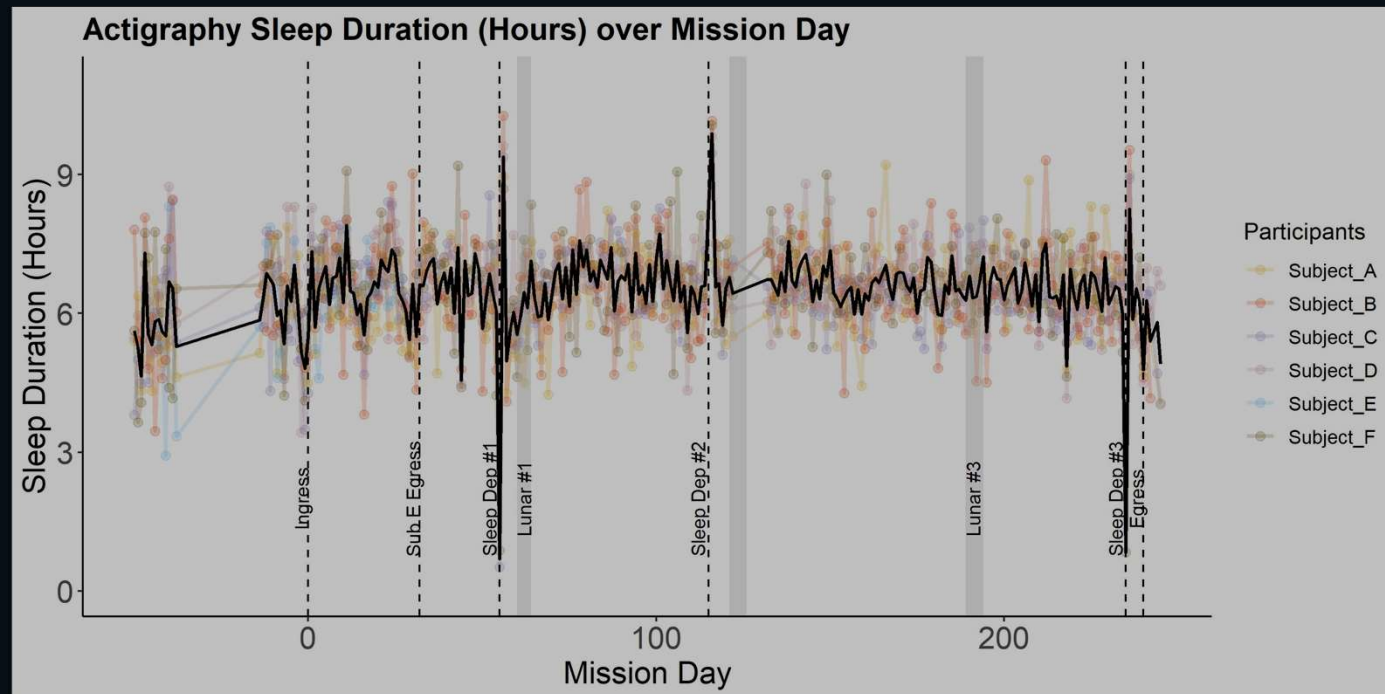
# Actigraphy Sleep Duration



Wrist accelerometer

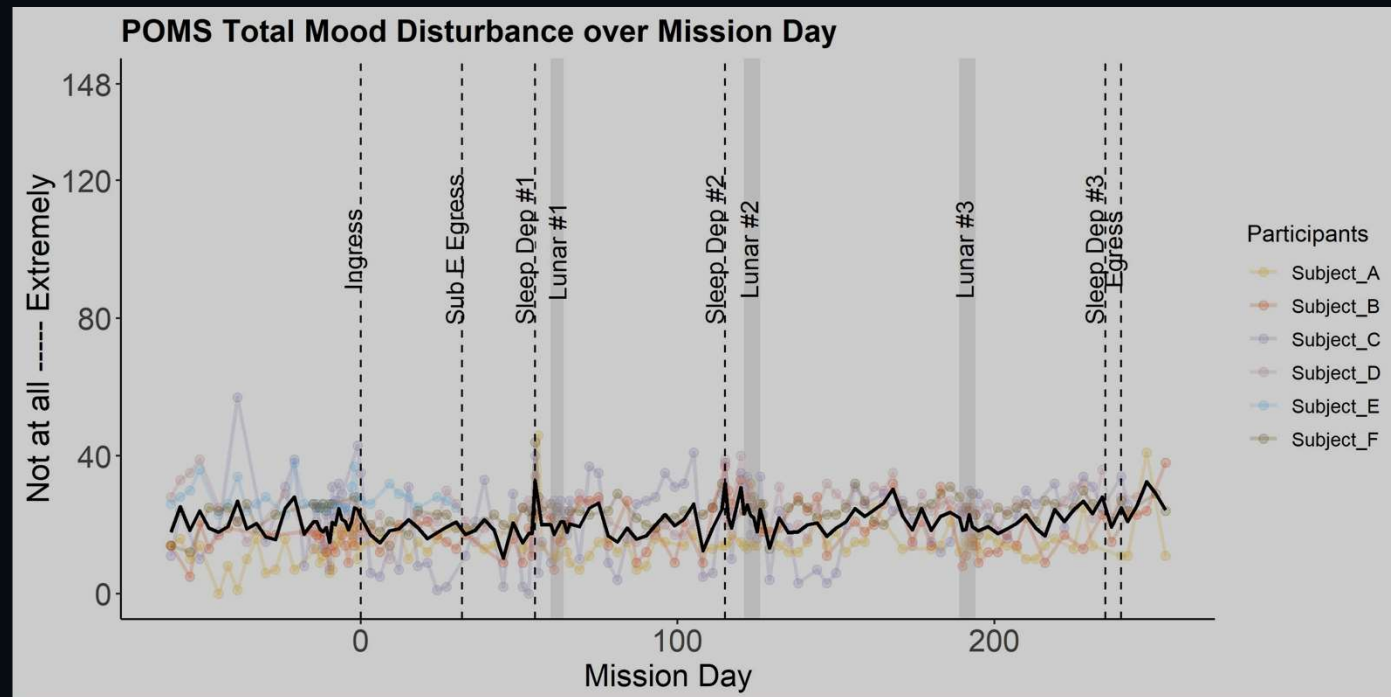
Photo credit:  
NASA/BHP Lab

- 6.5 hours of sleep on average
- Similar to ISS
- Sleep deprivations disrupted sleep



# Depression and Mood

- Low levels of mood disturbance and depression
- Sleep deprivations increased mood disturbances most before lunar landings



# Cognitive Performance

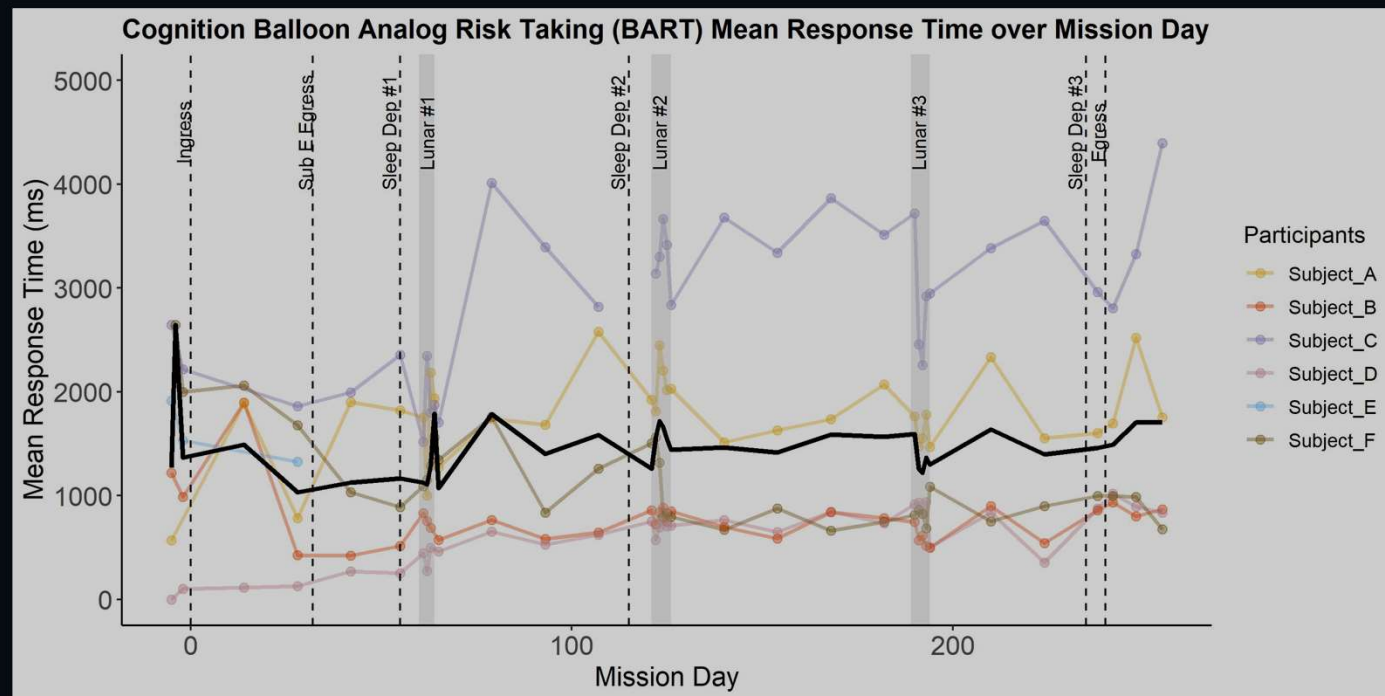
- Cognition battery
- 10 subtests, 15 alternate versions
- Administered in-mission bi-weekly in SIRIUS21
- Primary metrics include a speed and accuracy score for each subtest

Test	Cognitive Domains Assessed
Motor Praxis	Sensorimotor speed
Visual Object Learning	Spatial learning and working memory
Fractal 2-Back (N-back)	Working memory
Abstract Matching	Abstraction, concept formation
Line Orientation	Spatial orientation
Emotion Recognition	Emotion identification
Matrix Reasoning	Abstract reasoning
Digit Symbol Substitution	Complex scanning and visual tracking
Balloon Analog Risk	Risk decision making
Psychomotor Vigilance	Vigilant attention

Basner et al., 2015

# Cognitive Performance

- Variability in cognitive performance around lunar landing EVAs
- Performance during EVAs varied by cognitive domain tested



## Operationally Relevant Performance (ROBoT-r)

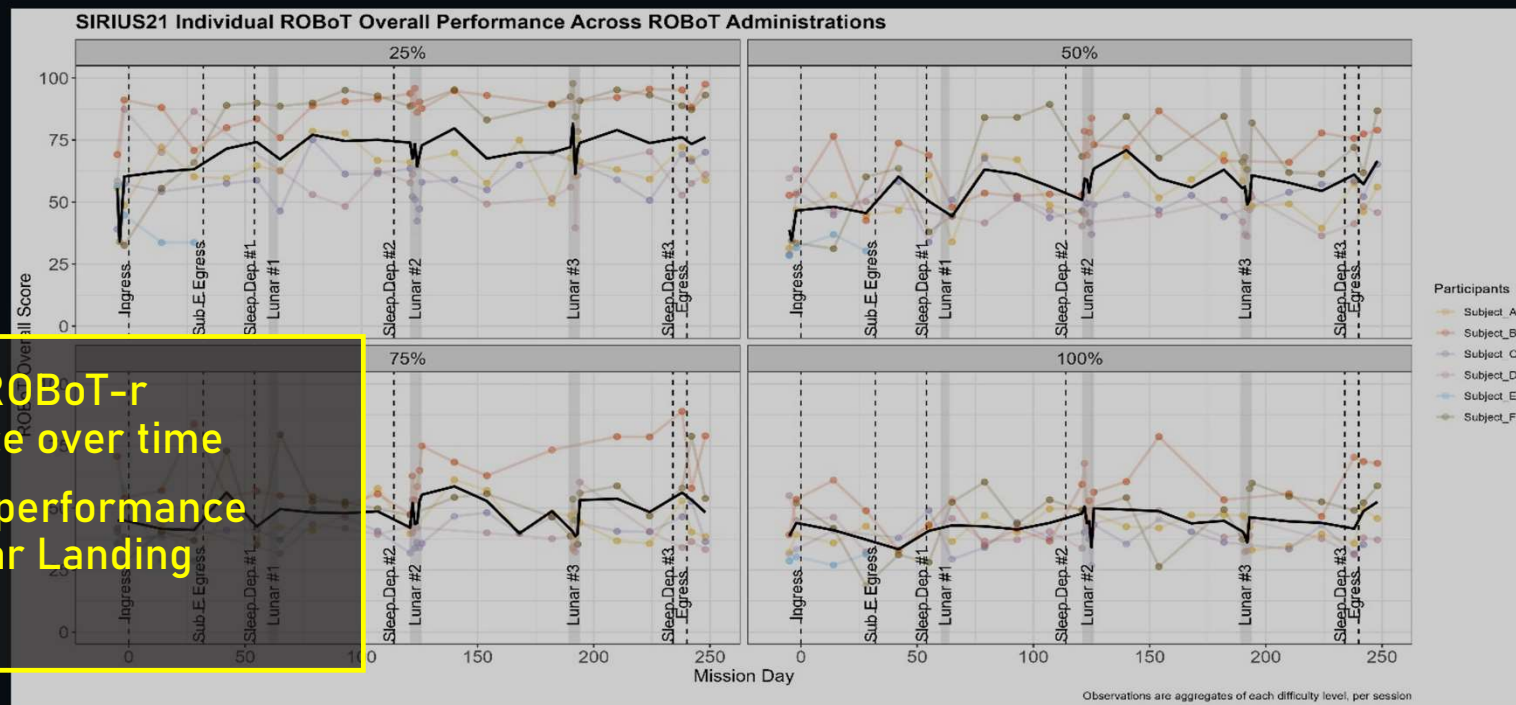
- Research adaptation of an astronaut training simulation of Canadarm2 docking procedures on the ISS
- Administered bi-weekly in SIRIUS21
- Primary outcome metrics include speed, approach accuracy, and overall score



Astronaut Shane Kimbrough on the ISS  
Photo credit: NASA

Ivkovik et al., 2019

# ROBoT-r Overall Score over Mission Day

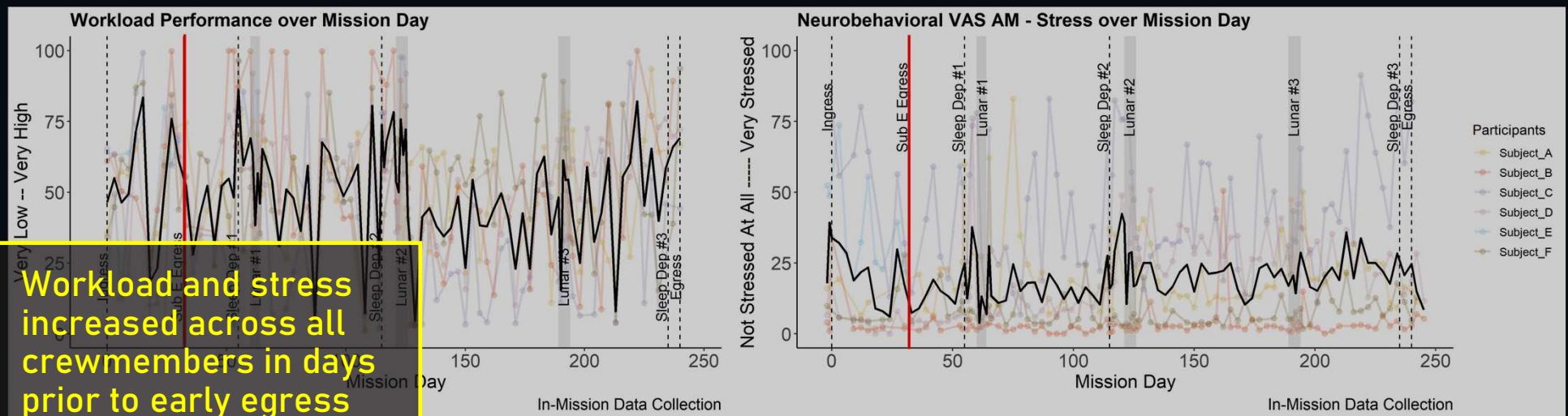


- Increased ROBoT-r performance over time
- Decreased performance during Lunar Landing EVAs



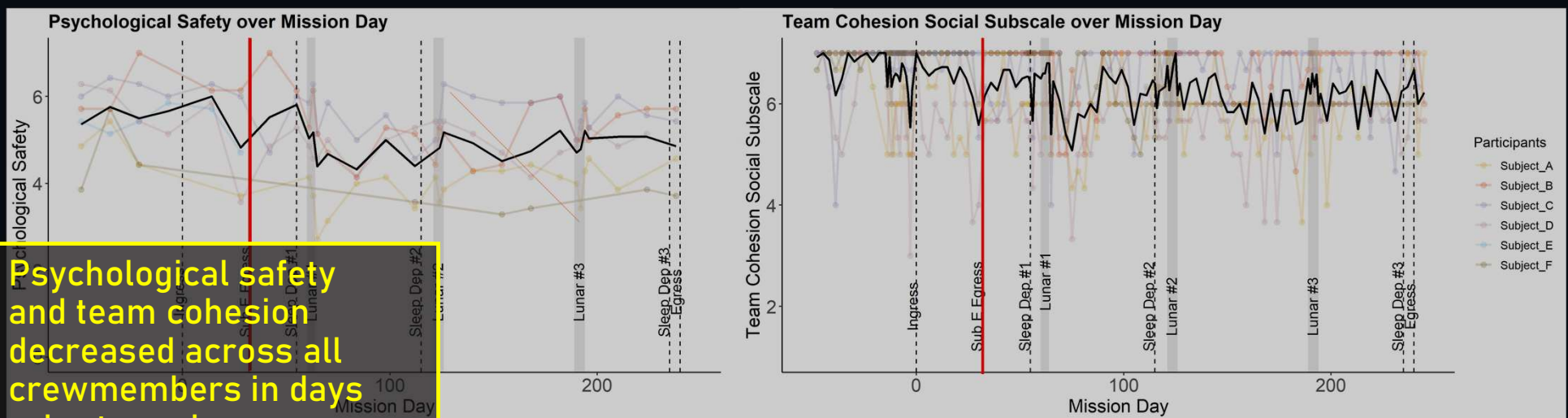
# Supplemental Aim Results

Assessing impact of crewmember early egress.



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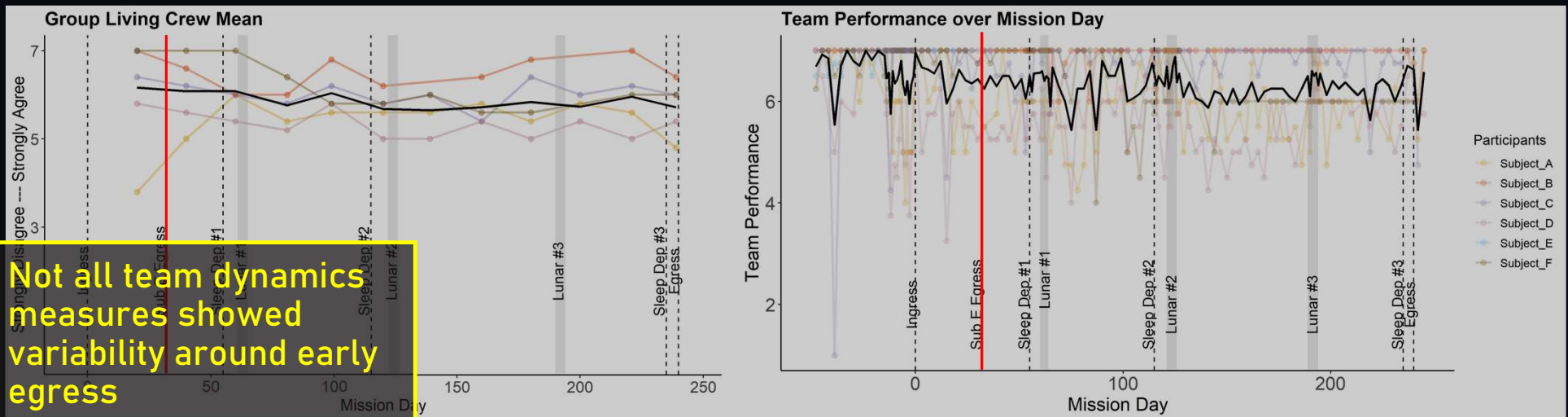
Assessing impact of crewmember early egress.



- Psychological safety and team cohesion decreased across all crewmembers in days prior to early egress

# Supplemental Aim Results

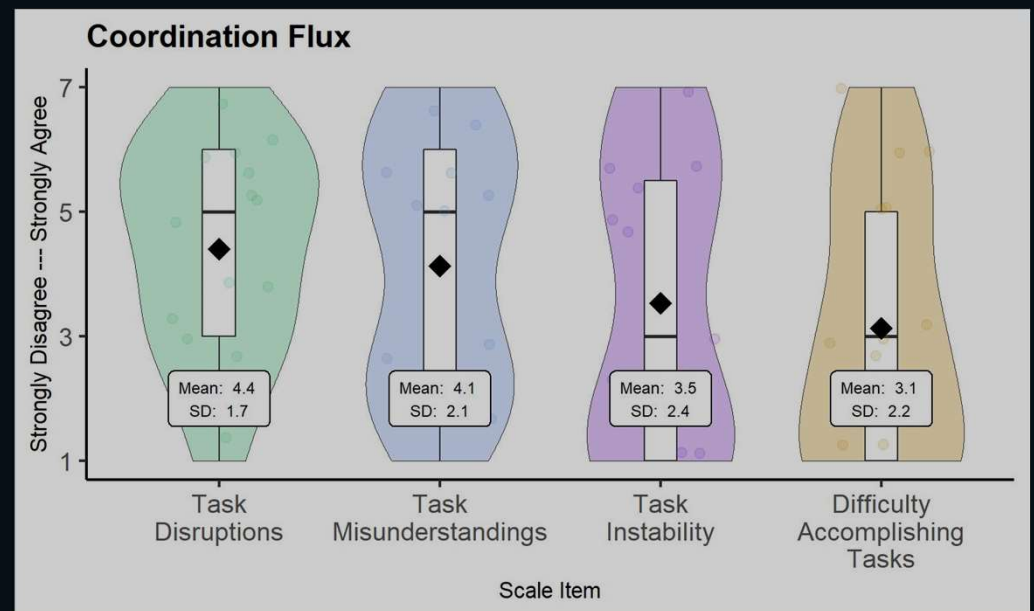
Assessing impact of crewmember early egress.



# Supplemental Aim Results

Assessing impact of crewmember early egress.

- Moderate-to-low agreement that early egress negatively impacted task performance



# NEK-SIRIUS21 Key Findings

1. Assess Operational Feasibility of HFBP-EM in the Russian NEK space analog.

High operational feasibility

2. Assess Operational Acceptability of HFBP-EM in the Russian NEK space analog.

Mixed operational acceptability

4. Enable comparisons of multiple missions across spaceflight analog campaigns to quantify risk using reliable metric-based data.

- Sleep: Average duration similar to ISS; decreased during sleep deprivations
- Depression and mood: Low depression and mood; mood disturbances increased during sleep deprivations
- ROBoT-r: Improvements over time; decrements in performance during lunar landing EVA scenarios
- Cognition: Variability in cognitive performance around lunar landing EVAs varying by cognitive domain tested

**Supplemental Aim:** Assessing impact of crewmember early egress.

- Teams: Workload and stress increased, psychological safety and team cohesion decreased, in days prior to early egress



## Next Steps

- Advanced statistical modeling
- Characterize HRP behavioral medicine, team, sleep, and some HSIA risk gaps
- Identify HRP risk mitigation strategies in long duration spaceflight
- Data collaboration
- Normative datasets to identify operationally relevant thresholds (i.e., norms)
- Integrated into a user-friendly dashboard for real-time decision making





## Literature Cited

- Basner, M., Savitt, A., Moore, T. M., Port, A. M., McGuire, S., Ecker, A. J., Nasrini, J., Mollicone, D. J., Mott, C. M., McCann, T., Dinges, D. F., & Gur, R. C. (2015). Development and Validation of the Cognition Test Battery for Spaceflight. *Aerosp Med Hum Perform*, 86(11), 942-952.  
<https://doi.org/10.3357/amhp.4343.2015>
- Ivkovic, V., Sommers, B., Cefaratti, D. A., Newman, G., Thomas, D. W., Alexander, D. G., & Strangman, G. E. (2019). Operationally relevant behavior assessment using the robotic on-board trainer for research (ROBoT-r). *Aerospace medicine and human performance*, 90(9), 819-825.



# Thank you! Questions?

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